
**स्वचल वाहन — चलती वाहनों द्वारा शोर का
उत्सर्जन — विशिष्ट एवं मापन पद्धति**
भाग 3 एल 5 श्रेणी

**Automotive Vehicles — Noise
Emitted by Moving Vehicles —
Specification and Method
of Measurement**

Part 3 L5 Category

ICS 17.140.30

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Automotive Braking and Steering System, Vehicle Testing and Performance Evaluation Sectional Committee had been approved by the Transport Engineering Division Council.

The requirements of noise emitted by moving vehicles were earlier covered in IS 3028 : 1998 'Automotive Vehicles — Noise emitted by moving vehicles — Method of measurement (*second revision*)'.

While reviewing this standard the Committee responsible for the formulation of this standard has decided to revise the standard based on latest Economic Commission for Europe, (ECE) regulations. As ECE regulations are different for two wheelers, three wheelers and other M (that is, vehicles having at least four wheels and used for the carriage of passengers, example, standard car with 2, 3, 4 doors) and N (that is, Power-driven vehicles having at least four wheels and used for the carriage of goods) category of vehicles. It was also decided to split this standard into different parts.

While this Part 3 covers noise emitted by L5 category vehicles in moving condition, whereas, the other parts cover:

- a) Part 1 covers noise emitted by L2 category vehicles; and
- b) Part 2 covers noise emitted by vehicles other than L2 and L5 category vehicles.

This Part is based on the requirements in the United Nations Economic Commission for Europe (UN ECE) Regulation 9, Rev.3 incorporating all valid text up to Supplement 1 to the 07 series of amendments — Date of entry into force: 20 January 2016 (ECE/TRANS/505/Add.8/Rev.3/Amend.1), for noise test in moving condition for L5 category vehicles.

The stationary noise emitted by vehicles is covered separately by IS 10399:1998 'Automotive vehicles — Noise emitted by stationary vehicles — Method of measurement (*first revision*)'.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same that of the specified value in this standard.

Indian Standard

AUTOMOTIVE VEHICLES — NOISE EMITTED BY MOVING VEHICLES — SPECIFICATION AND METHOD OF MEASUREMENT

PART 3 L5 CATEGORY VEHICLES

1 SCOPE

This standard specifies the method for measuring the external noise emitted in moving condition by category L5 vehicles as defined in IS 14272 : 2011.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<i>IS No.</i>	<i>Title</i>
IS 3028 : 1998	Automotive Vehicles — Noise emitted by moving vehicles — Method of measurement (<i>second revision</i>)
IS 9211 : 2003	Terms and definitions of weights of road vehicles other than 2 wheelers
IS 14272 : 2011	Automotive vehicles — Types — Terminology (<i>first revision</i>)
IS 14599 : 1999	Automotive vehicles — Performance requirements (measurement of power, SFC, opacity) of Positive and compression ignition engines — Method of test
ISO 2559 : 2011	Textile glass — Mats (made from chopped or continuous strands) — Designation and basis for specifications
ISO 3310-1 : 2016	Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth
ISO 10844 : 2014	Acoustics — Specification of test tracks for measuring noise emitted by road vehicles and their tyres

IS No.

Title

IEC 60942 : 2003	Electroacoustics — Sound calibrators
IEC 616721 : 2002	Electroacoustics — Sound level meters — Part 1: Specifications

3 DEFINITIONS

For the purposes of this Standard following definitions shall apply:

3.1 Approval of a Vehicle

Means the approval of a vehicle type with regard to the noise level and the original exhaust system as a technical unit.

3.2 Vehicle Type

Means a category of motor vehicles which do not differ in such essential respects as:

- a) The type of engine (positive ignition or compression ignition; reciprocating or rotary piston, number and capacity of cylinders, number and type of carburettors or injection systems, arrangement of valves, rated maximum net power and rated engine speed);
For rotary piston engines, the cubic capacity should be taken to be double of the volume of the chamber;
- b) *Rated maximum net power* — Means the rated engine power as defined in IS 14599 : 1999.
- c) *Rated engine speed* — Means the engine speed at which the engine develops its rated maximum net power as stated by the manufacturer;
- d) Number and ratios of gears;
- e) The number, type and arrangement of exhaust systems.

3.3 Exhaust or Silencing System(s)

Means a complete set of components necessary for limiting the noise made by a motor vehicle and its exhaust.

3.4 Exhaust or Silencing Systems of Different Types

Means exhaust or silencing systems which differ in such essential respects as:

- a) That their components bear different trade names or marks;
- b) That the characteristics of the materials constituting a component are different or that the components differ in shape or size;
- c) That the operating principles of at least one component are different;
- d) That their components are assembled differently.

3.5 Kerb Mass

Means the mass of the vehicle ready for normal operation as defined in IS 9211.

3.6 Maximum Speed

Mans the maximum vehicle speed as stated by the manufacturer.

4 APPLICATION FOR APPROVAL

The application for approval of a vehicle type with regard to noise shall be submitted by its manufacturer or by his duly accredited representative.

5 APPROVAL OF VEHICLE

5.1 If the vehicle type submitted for approval meets the requirements of **6**, approval of that vehicle type shall be granted.

5.2 Information to be submitted at the time of application for type approval shall be as given in Annex A.

NOTE — In case the details are already submitted during first type approval then, full details need not to be submitted again in subsequent approvals.

5.3 Modification and Extension of the Approval of the vehicle Type or of the Type of Exhaust or Silencing System(s)

Every modification of the vehicle type or of the exhaust or silencing system declared in accordance with **5.2** shall be intimated to the testing agency; testing agency may then consider, whether;

- a) The modifications made are unlikely to have appreciable adverse effects;
- b) Any further test is required; and
- c) For considering whether testing is required or not, guidelines given in Annex D shall be followed.

5.4 Transitional Provisions

5.4.1 At the request of the applicant, type approvals for compliance to this standard shall be granted by test agencies from (date of adoption in CMVR-TSC). Such type approvals shall be deemed for compliance to IS 3028 : 1998.

5.4.2 At the request of the applicant, type approvals for compliance to IS 3028 : 1998 shall be granted up to the notified date of implementation of this standard.

5.4.3 Type approvals issued for compliance to IS 3028 : 1998 shall be extended to approval of this standard subject to verification of Annex B.

6 SPECIFICATIONS

6.1 General Specification

6.1.1 The vehicle, its engine and its exhaust or silencing system(s) shall be so designed, constructed and assembled as to enable the vehicle, in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Standard.

6.1.2 The exhaust or silencing system(s) shall be so designed, constructed and assembled as to be able to resist the corrosive action to which it is exposed.

6.2 Specifications Regarding Sound Levels

6.2.1 The sound emissions of the vehicle type submitted for approval shall be measured by the method described in Annex B.

6.2.1 The test results obtained in accordance with the provisions of **6.2.1** shall be entered in the test report.

7 MARKINGS

The components of the exhaust or silencing system shall bear at least the following identifications. Such markings shall be indelible, clearly legible and also visible, in the position at which it is to be fitted to the vehicle.

- a) The trade description given by the manufacturer if any; and
- b) Exhaust system with identification (if proprietary) or part no (if non-proprietary).

ANNEX A

(Clause 5.1.1)

INFORMATION TO BE SUBMITTED BY MANUFACTURER

A-1 Trade name or mark of vehicle	A-9 Rated engine speed (minus 1)
A-2 Vehicle type	A-10 Number of gears
A-2.1 Variant(s) (as necessary)	A-11 Gears used
A-2.2 Version(s) (as necessary)	A-12 Final drive ratio(s)
A-3 Manufacturer's name and address	A-13 Type and dimensions of tyres (by axle)
A-4 If applicable, name and address of manufacturer's representative	A-14 Maximum permissible weight including semi-trailer (where applicable)
A-5 Kind of engine, example, positive-ignition, compression ignition, etc. (Note — If a non-conventional engine is used, this should be stated.)	A-15 Brief description of the exhaust system:
A-6 Cycles: two-stroke or four-stroke (if applicable)	A-15.1 Type(s) of exhaust system(s):
A-7 Cylinder capacity (if applicable)	A-15.2 Type(s) of intake system(s) (if necessary)
A-8 Rated maximum net power (method of measurement)	A-16 A drawing of the assembled exhaust or silencing system and an indication of its position on the vehicle;

ANNEX B

(Clause 6.2.1)

METHODS AND INSTRUMENTS FOR MEASURING THE NOISE MADE BY MOTOR VEHICLES**B-1 MEASURING INSTRUMENTS****B-1.1 General**

The apparatus used for measuring the sound pressure level shall be a sound level meter or equivalent measuring system meeting the requirements of class 1 instruments (inclusive of the recommended windscreen, if used). These requirements are described in IEC 61672-1 : 2002. Measurements shall be carried out using the time weighting “F” of the acoustic measuring instrument and the “A” frequency weighting curve also described in IEC 61672-1 : 2002. When using a system that includes periodic monitoring of the A weighted sound pressure level, a reading should be made at a time interval not greater than 30 m. The instruments shall be maintained and calibrated in accordance with the instructions of the instrument manufacturer.

B-1.2 Calibration

At the beginning and at the end of every measurement session, the entire acoustic measuring system shall be checked by means of a sound calibrator that fulfils the requirements of class 1 sound calibrators according to IEC 60942 : 2003. Without any further adjustment, the difference between the readings shall be less than or equal to 0.5 dB (A). If this value is exceeded, the results of the measurements obtained after the previous satisfactory check shall be discarded.

B-1.3 Compliance with Requirements

Compliance of the sound calibrator with the requirements of IEC 60942 : 2003 shall be verified once a year. Compliance of the instrumentation system with the requirements of IEC 61672-1 : 2002 shall be verified at least every 2 years. All compliance testing shall be conducted by a laboratory which is authorized to perform calibrations traceable to the appropriate standards.

B-1.4 Instrumentation for Speed Measurement

The rotational speed of the engine shall be measured with an instrument meeting specification limits of at least ± 2 percent or better at the engine speeds required for the measurements being performed. The road speed of the vehicle shall be measured with instruments meeting specification limits of at least ± 0.5 km/h when using continuous measuring devices. If testing uses independent measurements of speed, this instrumentation shall meet specification limits of at least ± 0.2 km/h

B-1.5 Meteorological Instrumentation

The meteorological instrumentation used to monitor the environmental conditions during the test shall meet the following specifications:

- a) $\pm 1^\circ\text{C}$ or less for a temperature measuring device;
- b) ± 1.0 m/s for a wind speed measuring device;
- c) ± 5 h Pa for a barometric pressure measuring device; and
- d) ± 5 percent for a relative humidity measuring device.

B-2 CONDITIONS OF MEASUREMENT**B-2.1 Condition of the Vehicle****B-2.1.1 General Conditions**

The vehicle shall be supplied as specified by the vehicle manufacturer.

Before the measurements are started, the vehicle shall be brought to its normal operating conditions.

B-2.1.2 If the vehicle is fitted with fans with an automatic actuating mechanism, this system shall not be interfered with during the sound measurements. For vehicles having more than one driven wheel, only the drive provided for normal road operation may be used. If the vehicle is fitted with a semi-trailer, this shall be removed for the purposes of the test.

B-2.1.3 The tests shall not be carried out if the wind speed, including gusts, exceeds 5 m/s during the sound-measurement interval.

B-2.1.2 Test Mass of the Vehicle

Measurements shall be made on vehicles at the following test mass (m_t), in kg, specified as:

$$m_t = m_{\text{kerb}} + 75 \pm 5 \text{ kg}$$

where,

m_{kerb} = kerb mass, in kg; and

75 ± 5 kg equates to mass of the driver and instrumentation.

B-2.1.3 Tyre Selection and Condition

The tyres shall be appropriate for the vehicle and shall be inflated to the pressure recommended by the vehicle manufacturer for the test mass of the vehicle.

The tyres shall be selected by the vehicle manufacturer, and correspond to one of the tyre sizes and types designated for the vehicle by the vehicle manufacturer. The minimum tread depth shall be at least 80 percent of the full tread depth.

B-2.2 The test site shall consist of a central acceleration track surrounded by a substantially level test area. The test track shall be level the track surface shall be dry and so designed that tyre noise remains low.

On the test site, free sound field conditions shall be maintained to within ± 1 dB between the sound source placed in the middle of the acceleration section and the microphone. This condition shall be deemed to be met if there are no large sound-reflecting objects such as fences, rocks, bridges or buildings within 50 m of the centre of the acceleration section. The surface of the test track shall conform to the requirements of Annex C to this Standard or to ISO 10844 : 2014.

No obstacle likely to affect the sound field shall be close to the microphone and no one shall come between the microphone and the sound source. The observer taking the measurements shall take up position so as to avoid influencing the metre readings.

B-2.3 Miscellaneous

Measurements shall not be made in poor weather conditions. For measurement purposes, the weighted sound-level (A) of sound sources other than on the test vehicle and the sound-level produced by the effect of the wind shall be at least 10 dB (A) below the noise-level produced by the vehicle. The microphone may be fitted with a suitable wind-guard, provided that its influence

on the sensitivity and directional characteristics of the microphone are taken into account.

If the difference between ambient and measured noise-levels is between 10 and 15 dB (A), in order to calculate the test result the appropriate correction shall be subtracted from the readings on the sound level meter, as given in Table 1.

B-3 METHODS OF MEASUREMENT

B-3.1 Measurement of Noise of Vehicles in Motion

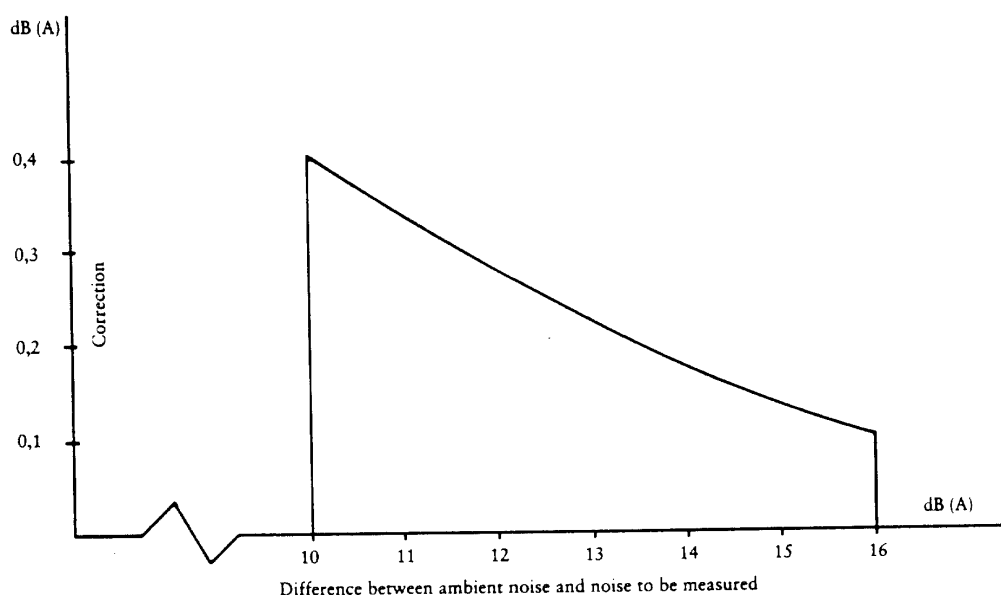
B-3.1.1 Positions for the Test

B-3.1.1.1 The maximum weighted sound-level (A), expressed in decibels (dB), shall be measured as the vehicle is driven between lines AA' and BB' (Figure.1). The measurement shall be invalid if an abnormal discrepancy between the peak value and the general sound-level is recorded.

At least two measurements shall be made on each side of the vehicle.

Preliminary measurements may be made for adjustment purposes, but shall be disregarded.

B-3.1.1.2 The distance of the microphone positions from the line CC', on the microphone line PP', perpendicular to the reference line CC' on the test track (Figure 1 below), shall be 7.5 ± 0.05 m. The microphones shall be located 1.2 ± 0.02 m above the ground level. The reference direction for free-field conditions (*see* IEC 61672-1 : 2002) shall be horizontal and directed perpendicularly towards the path of the vehicle line CC'.



$$y = -0.1 \times x + 1.5$$

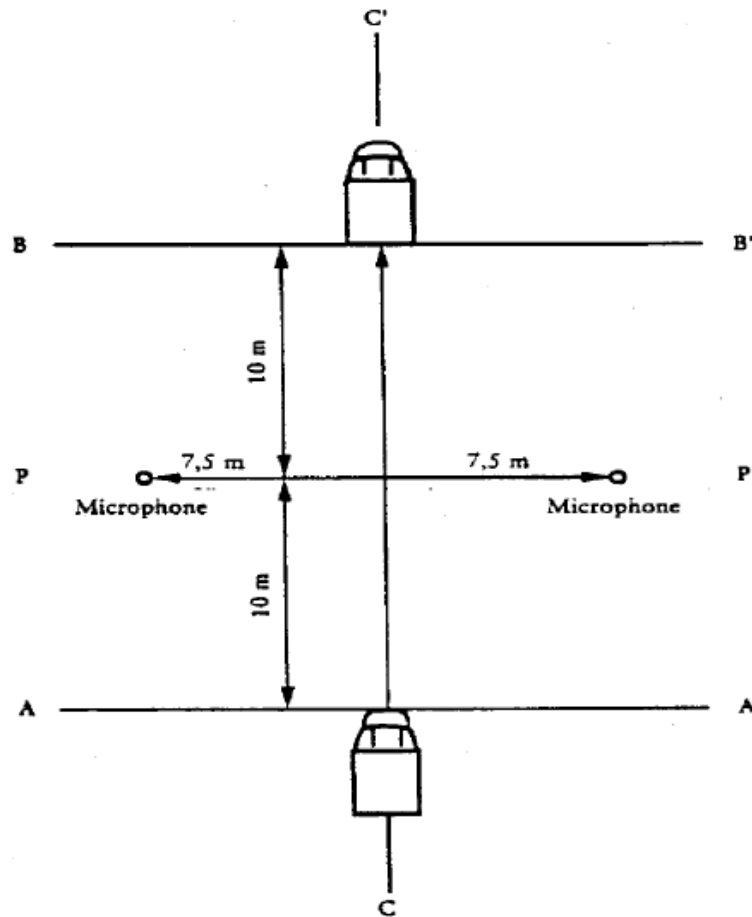


FIG. 1 POSITIONS FOR TESTING THE VEHICLE IN MOTION

B-3.1.1.3 Two lines, AA' and BB', parallel to line PP' and situated respectively 10 m forward and 10 m rearward of that line shall be marked out on the test runway. The vehicle shall approach line AA' at a steady speed as specified below. The throttle shall then be fully opened as rapidly as practicable and held in the fully-opened position until the rear of the vehicle crosses line BB'; the throttle shall then be closed again as rapidly as possible.

B-3.1.1.4 In the case of articulated vehicles consisting of two non-separable units regarded as a single vehicle, the semi-trailer shall be disregarded in determining when line BB' is crossed.

B-3.1.1.5 The result of the measurement shall be determined in accordance with **B-4** of this annex.

B-3.1.2 *Determination of the Steady Speed*

B-3.1.2.1 *Vehicle with no gearbox*

The vehicle shall approach line AA' at a steady speed corresponding either, in terms of engine speed (minus 1), to three-quarters of the rated engine speed or to three-quarters of the maximum engine speed permitted by the governor, or to 50 km/h, whichever is the lowest.

B-3.1.2.2 *Vehicle with a manually-operated gearbox*

If the vehicle is fitted with a two-speed, a three-speed or a four-speed gearbox, the second gear shall be used. If the vehicle has more than four speeds, the third gear shall be used. If, by following the above procedure, the engine speed developed exceeds its maximum permissible regime, the first higher gear which ensures that this regime is no longer exceeded up to the line BB' of the measurement area should be used instead of the second or third gear. Auxiliary step up ratios ("overdrive") shall not be engaged. If the vehicle is fitted with a differential with two gear ratios, the ratio selected shall be that allowing the highest vehicle speed. The vehicle shall approach line AA' at a steady speed corresponding either, in terms of engine speed, to three quarters of the rated engine speed or to three-quarters of the maximum engine speed permitted by the governor, or to 50 km/h, whichever is the lowest.

B-3.1.2.3 *Vehicle with an automatic transmission*

The vehicle shall approach the line AA' at a steady speed of 50 km/h or at three-quarters of its maximum speed, whichever is the lower. Where several forward-drive positions are available, that position

shall be selected which results in the highest mean acceleration of the vehicle between lines AA' and BB'. The selector position which is used only for engine braking, parking or similar slow manoeuvres shall not be used.

B-4 INTERPRETATION OF RESULTS FOR VEHICLES IN MOTION

B-4.1 The values taken shall be rounded off to the nearest whole decibel. If the figure following the decimal point is between 0 to 4, the total is rounded down and, if between 5 to 9, it is rounded up.

B-4.2 Only the values of readings obtained from two consecutive measurements made on the same side of the vehicle and not differing by more than 2 dB (A) shall be accepted.

B-4.3 To allow for lack of precision in the readings, the result of each measurement shall be taken as equal to the value obtained, minus 1 dB (A).

B-4.4 If the average of the four readings does not exceed the maximum permissible level as specified in the *Central Motor Vehicles Rules (CMVR) 120*, for three wheelers, it shall be deemed as being complied with. This average value shall constitute the test result.

B-5 EXHAUST (SILENCING) SYSTEM

B-5.1 Requirements for Silencers Containing Absorbent Fibrous Materials

B-5.1.1 Fibrous absorbent material shall be asbestos-free and may be used in the construction of silencers only if suitable devices ensure that the fibrous absorbent material is kept in place for the whole time that the silencer is being used and the exhaust or silencing system meets the requirements of any one of **B-5.1.2**, **B-5.1.3**, **B-5.1.4** and **B-5.1.5**.

B-5.1.2 After removal of the fibrous material, the sound-level must conform to the requirements of **B-4**.

B-5.1.3 The fibrous absorbent material may not be placed in those parts of the silencer through which the exhaust gases pass and must conform to the following requirements:

- The material shall be heated at a temperature of $650 \pm 5^\circ\text{C}$ for 4 h in a furnace without reduction in the average length, diameter or bulk density of the fibre;
- After heating at $650 \pm 5^\circ\text{C}$ for 1 h in a furnace, at least 98 percent of the material shall be retained in a sieve of nominal aperture size 250 conforming to ISO 3310-1 : 2016, when tested in accordance with ISO 2559 : 2011; and

c) The loss in weight of the material shall not exceed 10.5 percent after soaking for 24 h at $90 \pm 5^\circ\text{C}$ in a synthetic condensate of the following composition:

- 1 N hydrobromic acid (HBr), 10 ml;
- 1 N sulphuric acid (H_2SO_4), 10 ml; and
- Distilled water to make up the volume upto 1 000 ml.

Note — The material must be washed in distilled water and dried for 1 h at 105°C before weighing.

B-5.1.4 Before the system is tested in accordance with **B-3**, it must be put into a normal state for road use by one of the following methods:

B-5.1.4.1 Conditioning by continuous road operation

B-5.1.4.1.1 Depending on the engine capacity of the vehicle, the minimum distances to be completed during conditioning shall be:

Category of vehicle according to cylinder capacity in cm^3	Distance (km)
1. ≤ 250	4000
2. $> 250 \leq 500$	6000
3. > 500	8000

Note — The running may be carried out by vehicle manufacturers and their declaration given.

B-5.1.4.1.2 Fifty \pm 10 percent of this conditioning cycle shall consist of town driving and the remainder of long-distance runs at high speed, the continuous road cycle may be replaced by a corresponding test-track programme.

B-5.1.4.1.3 The two speed regimes must be alternated at least six times.

B-5.1.4.1.4 The complete test programme shall include a minimum of 10 breaks of at least 3 h duration in order to reproduce the effects of cooling and condensation.

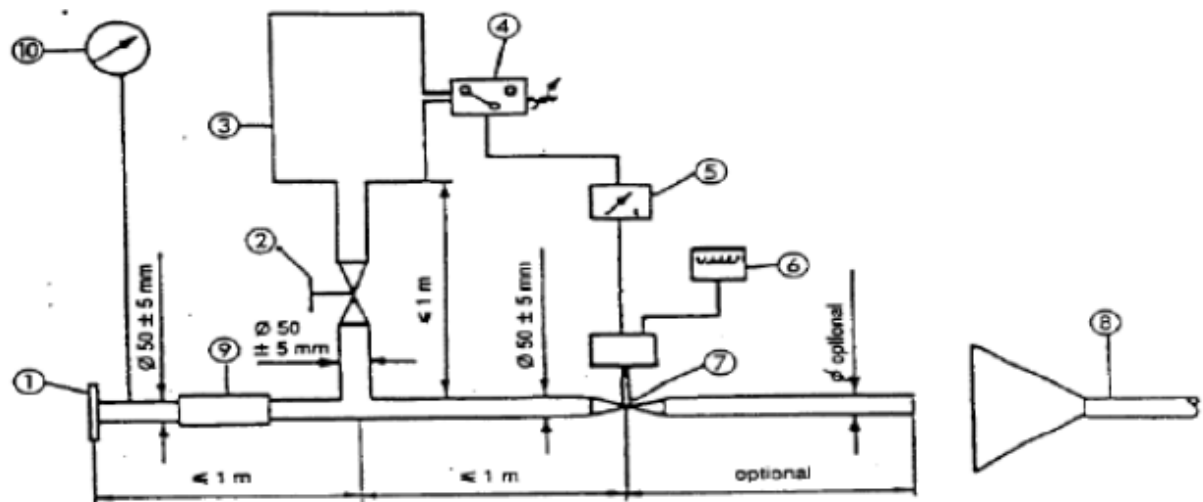
B-5.1.4.2 Conditioning by pulsation

B-5.1.4.2.1 The exhaust system or components thereof must be fitted to the vehicle or to the engine.

In the former case, the vehicle must be mounted on a roller dynamometer. In the second case, the engine must be mounted on a test bench.

The test apparatus, a detailed diagram of which is shown in Figure 2, shall be fitted at the outlet of the exhaust system. Any other apparatus providing equivalent results shall be acceptable.

B-5.1.4.2.2 The test equipment shall be adjusted so that the flow of exhaust gases is alternately interrupted and restored 2 500 times by a rapid-action valve.



1. Inlet flange or sleeve for connection to the rear of the test exhausts system.
2. Hand-operated regulating valve.
3. Compensating reservoir with a maximum capacity of 40 l and a filling time of not less than one second.
4. Pressure switch with an operating range of 5 to 250 kPa.
5. Time delay switch.
6. Pulse counter.
7. Quick-acting valve, such as exhaust brake valve 60 mm in diameter, operated by a pneumatic cylinder with an output of 120 N at 400 kPa. The response time, both when opening and closing, must not exceed 0.5 s.
8. Exhaust gas evacuation.
9. Flexible pipe.
10. Pressure gauge.

FIG. 2 TESTING APPARATUS FOR CONDITIONING BY PULSATION

(see B-5.1.4.2.1)

B-5.1.4.2.3 The valve shall open when the exhaust gas back-pressure, measured at least 100 mm downstream of the intake flange, reaches a value of between 35 and 40 kPa. Should such a figure be unattainable because of the engine characteristics, the valve shall open when the gas back-pressure reaches a level equivalent to 90 percent of the maximum that can be measured before the engine stops. It shall close when this pressure does not differ by more than 10 percent from its stabilized value with the valve open.

B-5.1.4.2.4 The time-delay switch must be set for the duration of exhaust gases calculated on the basis of the requirements of B-5.1.4.2.3.

B-5.1.4.2.5 Engine speed must be 75 percent of the speed (S) at which the engine develops maximum power.

B-5.1.4.2.6 The power indicated by the dynamometer shall be 50 percent of the full-throttle power measured at 75 percent of the rated engine speed (S).

B-5.1.4.2.7 Any drainage holes must be closed off during the test.

B-5.1.4.2.8 The entire test must be completed within 48 h. If necessary, a cooling period shall be allowed after each hour.

B-5.1.4.3 Conditioning on a test bench

B-5.1.4.3.1 The exhaust system must be fitted to an engine representative of the type fitted to the vehicle for which the system is designed, and mounted on a test bench.

B-5.1.4.3.2 Conditioning shall consist of the specified number of test-bench cycles for the category engine capacity of the vehicle for which the exhaust system was designed. The number of cycles for each vehicle category class shall be:

Category of vehicle according to cylinder capacity in cm ³	Number of cycles
1. ≤ 250	6
2. > 250 ≤ 500	9
3. > 500	12

B-5.1.4.3.3 Each test-bench cycle must be followed by a break of at least 6 h in order to reproduce the effects of cooling and condensation.

B-5.1.4.3.4 Each test-bench cycle shall consist of six phases. The engine conditions for, and the duration of, each phase shall be:

Phase	Condition	Duration of Phase	
		Engine of Less than 250 cm ³ (min)	Engine of 250 cm ³ or more (min)
1	Idling	6	6
2	25 percent load at 75 percent of S	40	50
3	50 percent load at 75 percent of S	40	50
4	100 percent load at 75 percent of S	30	10
5	50 percent load at 100 percent of S	12	12
6	25 percent load at 100 percent of S	22	22
Total time		2 h 30 min	2 h 30 min

B-5.1.4.3.5 During this conditioning procedure, at the request of the manufacturer, the engine and the silencer may be cooled in order that the temperature recorded at a point not more than 100 mm from the exhaust gas outlet does not exceed that measured when the vehicle is running at 110 km/h or 75 percent of sin top gear. The engine and/or vehicle speeds shall be determined to within ± 3 percent.

B-5.1.5 Exhaust gases are not in contact with fibrous materials and fibrous materials are not under the influence of pressure variations.

ANNEX C

(Clause B-2.2)

SPECIFICATIONS FOR THE TEST SITE

C-1 INTRODUCTION

This annex describes the specifications relating to the physical characteristics and the laying of the test track.

C-2 REQUIRED CHARACTERISTICS OF THE SURFACE

A surface is considered to conform to this standard provided that the texture and voids content or sound absorption coefficient have been measured and found to fulfill all the requirements of C-2.1 to C-2.4 and provided that the design requirements (C-3.2 below) have been met.

C-2.1 Residual Voids Content

The residual voids content, V_c , of the test track paving mixture shall not exceed 8 percent. For the measurement procedure (see C-4.1).

C-2.2 Sound Absorption Coefficient

If the surface fails to conform to the residual voids content requirement, the surface is acceptable only if its sound absorption coefficient, $\alpha \leq 0.10$. For the measurement procedure (see C-4.2). The requirement of C-2.1 and this C-2.2 are met also if only sound absorption has been measured and found to be $\alpha \leq 0.10$

Note — The most relevant characteristic is the sound absorption, although the residual voids content is more familiar among road constructors. However, sound absorption needs to be measured only if the surface fails to comply with the voids requirement. This is because the latter is connected with relatively large uncertainties in terms of both measurements and relevance and some surfaces therefore may be rejected erroneously on the basis of the voids measurement only.

C-2.3 Texture Depth

The texture depth (TD) measured according to the volumetric method (see C-4.3) shall be:

$$TD \geq 0.4 \text{ mm}$$

C-2.4 Homogeneity of the Surface

Every practical effort shall be made to ensure that the surface is made to be as homogeneous as possible within the test area. This includes the texture and voids content, but it should also be observed that if the rolling process results in more effective rolling at some places than at others, the texture may be different and unevenness causing bumps may also occur.

C-2.5 Period Of Testing

In order to check whether the surface continues to conform to the texture and voids content or sound

absorption requirements stipulated in this standard, periodic testing of the surface shall be done at the following intervals:

- a) For residual voids content or sound absorption — When the surface is new, if the surface meets the requirements when new, no further periodical testing is required; and
- b) For texture depth (TD) — When the surface is new when the noise testing starts.

Note — Not before 4 weeks after laying, then every 12 months.

C-3 TEST SURFACE DESIGN**C-3.1 Area**

When designing the test track layout it is important to ensure that, as a minimum requirement, the area traversed by the vehicles running through the test strip is covered with the specified test material with suitable margins for safe and practical driving. This will require the width of the track to be at least 3 m and the length of the track to extend beyond lines AA and BB by at least 10 m at either end. Figure 3 shows a plan of a suitable test site and indicates the minimum area which shall be machine laid and machine compacted with the specified test surface material. According to B-3.1.1.1., measurements have to be made on each side of the vehicle. This can be done either by measuring with two microphone locations (one on each side of the track) and driving in one direction, or measuring with a microphone only on one side of the track but driving the vehicle in two directions. If the latter method is used, then there are no surface requirements on that side of the track where there is no microphone.

C-3.2 Design And Preparation Of The Surface**C-3.2.1 Basic Design Requirements**

The test surface shall meet four design requirements:

- a) It shall be a dense asphaltic concrete;
- b) The maximum chipping size shall be 8 mm (tolerances allow from 6.3 to 10 mm);
- c) The thickness of the wearing course shall be ≥ 30 mm; and
- d) The binder shall be a straight penetration grade bitumen without modification.

C-3.2.2 Design Guidelines

As a guide to the surface constructor, an aggregate grading curve which will give desired characteristics is shown in Fig 4. In addition, Table 2 gives some

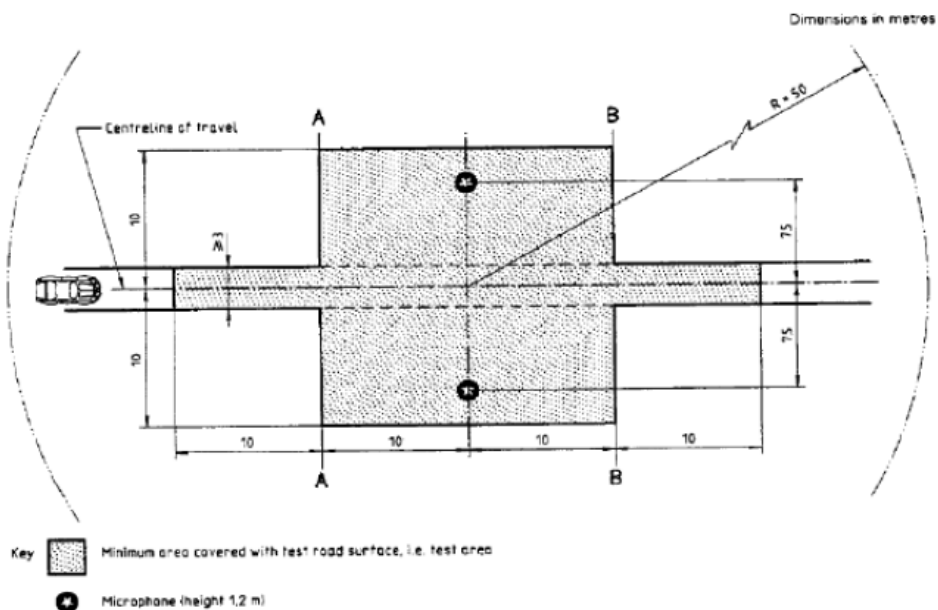


FIG. 3 MINIMUM REQUIREMENT FOR TEST SURFACE AREA.
THE SHADED PART IS CALLED "TEST AREA".

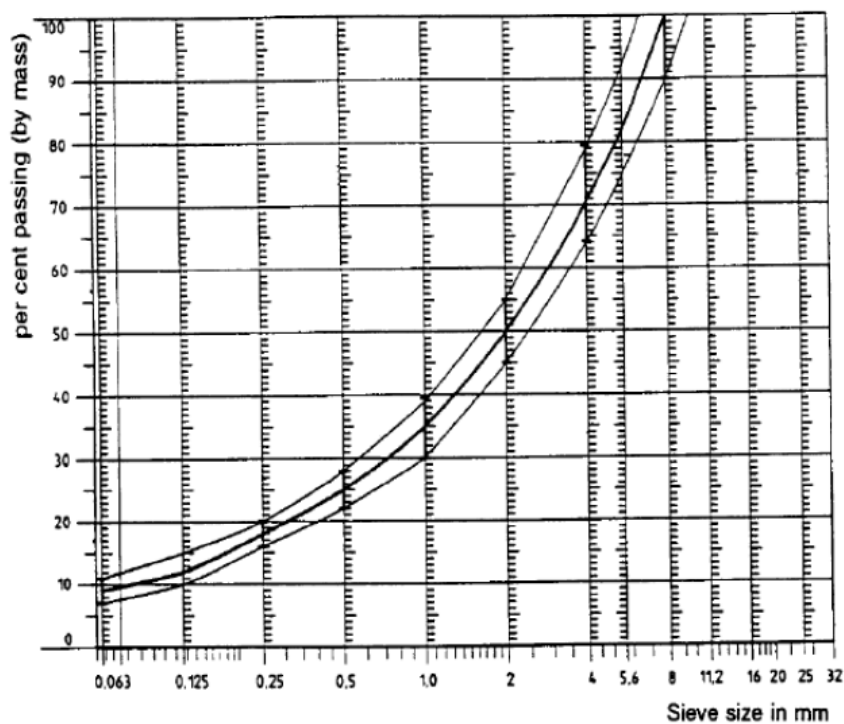


FIG. 4 GRADING CURVE OF THE AGGREGATE IN THE ASPHALTIC MIX
WITH TOLERANCES

Table 2 Design Guidelines
(Clause C-3.2.2)

Sl. No.	Target values		
	By Total Mass of Mix	By Total Mass of Aggregate	Tolerances
(1)	(2)	(3)	(4)
(i) Mass of stones, square mesh sieve (SM) > 2 mm	47.6 percent	50.5 percent	± 5
(ii) Mass of sand 0.063 < SM < 2 mm	38.0 percent	40.2 percent	± 5
(iii) Mass of filler SM < 0.063 mm	8.8 percent	9.3 percent	± 2
(iv) Mass of binder (bitumen)	5.8 percent	N.A	± 0.5
(v) Max. chipping size		8 mm	6.3 to 10
(vi) Binder hardness	[see C-3.2.2.(f)]		
(vii) Polished stone value (PSV)		> 50	
(viii) Compactness, relative to Marshall compactness		98 percent	

guidelines for obtaining the desired texture and durability. The grading curve fits the following formula:

$$P (\% \text{ passing}) = 100 \cdot (d/d_{\max})^{1/2}$$

where,

d = square mesh sieve size, in mm;

d_{\max} = 8 mm for the mean curve;

d_{\max} = 10 mm for the lower tolerance curve; and

d_{\max} = 6.3 mm for the upper tolerance curve.

In addition to the above, the following recommendations are given:

- The sand fraction (0.063 mm < square mesh sieve size < 2 mm) shall include no more than 55 percent natural sand and at least 45 percent crushed sand;
- The base and sub-base shall ensure a good stability and evenness, according to best road construction practice;
- The chippings shall be crushed (100 percent crushed faces) and of a material with a high resistance to crushing;
- The chippings used in the mix shall be washed;
- No extra chippings shall be added onto the surface;
- The binder hardness expressed as PEN value shall be 40-60, 60-80 or even 80-100 depending on the climatic conditions of the country. The rule is that as hard a binder as possible shall be used, provided this is consistent with common practice; and
- The temperature of the mix before rolling shall be chosen so as to achieve by subsequent rolling the required voids content. In order to increase the probability of satisfying the specifications of C-2.1 to C-2.4, the compactness shall be studied not only by an appropriate choice of mixing temperature, but also by an appropriate number of passing and by the choice of compacting vehicle.

C-4 TEST METHOD

C-4.1 Measurement of the Residual Voids Content

For the purpose of this measurement, cores have to be taken from the track in at least four different positions which are equally distributed in the test area between lines AA and BB (see Fig 3). In order to avoid in homogeneity and unevenness in the wheel tracks, cores should not be taken in wheel tracks themselves, but close to them. Two cores (minimum) should be taken close to the wheel tracks and one core (minimum) should be taken approximately midway between the wheel tracks and each microphone location.

If there is a suspicion that the condition of homogeneity is not met (see C-2.4), cores shall be taken from more locations within the test area. The residual voids content has to be determined for each core, then the average value from all cores shall be calculated and compared with the requirement of C-2.1. In addition, no single core shall have a voids value which is higher than 10 percent. The test surface constructor is reminded of the problem which may arise when the test area is heated by pipes or electrical wires and cores must be taken from this area. Such installations shall be carefully planned with respect to future core drilling locations. It is recommended that a few locations of size approximately 200 x 300 mm should be left where there are no wires/pipes or where the latter are located deep enough in order not to be damaged by cores taken from the surface layer.

C-4.2 Sound Absorption Coefficient

The sound absorption coefficient (normal incidence) shall be measured by the impedance tube method using the procedure specified in ISO/DIS 10 534 "Acoustics — Determination of sound absorption coefficient and impedance by a tube method".

Regarding test specimens, the same requirements shall be followed as regarding the residual voids content

(see C-4.1). The sound absorption shall be measured in the range between 400 Hz and 800 Hz and in the range between 800 Hz and 1 600 Hz (at least at the centre frequencies of third octave bands) and the maximum values shall be identified for both of these frequency ranges. Then these values, for all test scores, shall be averaged to constitute the final result.

C-4.3 Volumetric Macrotexture Measurement

For the purpose of this standard, texture depth measurements shall be made on at least 10 positions evenly spaced along the wheel tracks of the test strip and the average value taken to compare with the specified minimum texture depth. For the description of the procedure (see ISO 10844 : 1994).

C-5 STABILITY IN TIME AND MAINTENANCE

C-5.1 Age Influence

C-5.1.1 In common with any other surfaces, it is expected that the tyre/road noise level measured on the test surface may increase slightly during the first 6 to 12 months after construction.

C-5.1.2 The surface will achieve its required characteristics not earlier than four weeks after construction.

C-5.1.3 The stability over time is determined mainly by the polishing and compaction by vehicles driving on the surface. It shall be periodically checked as stated in C-2.5.

C-5.2 Maintenance of The Surface

Loose debris or dust which could significantly reduce the effective texture depth must be removed from the surface. In countries with winter climates, salt is sometimes used for de-icing. Salt may alter the surface temporarily or even permanently in such a way as to increase noise, and is therefore not recommended.

C-5.3 Repaving the Test Area

If it is necessary to repave the test track, it is usually unnecessary to repave more than the test strip (of 3 m width in Fig. 3) where vehicles are driving, provided the test area outside the strip met the requirement of residual voids content or sound absorption when it was measured.

C-6 DOCUMENTATION OF THE TEST SURFACE AND OF TESTS PERFORMED ON IT

C-6.1 Documentation of the Test Surface

The following data shall be given in a document describing the test surface:

- a) The location of the test track;
- b) Type of binder, binder hardness, type of aggregate, maximum theoretical density of the concrete (D_R), thickness of the wearing course and grading curve determined from cores from the test track;
- c) Method of compaction (example, type of roller, roller mass, number of passes);
- d) Temperature of the mix, temperature of the ambient air and wind speed during laying of the surface;
- e) Date when the surface was laid and name of the contractor; and
- f) All test results or at least the latest test result, including:
 - 1) The residual voids content of each core;
 - 2) The locations in the test area from where the cores for voids measurements have been taken;
 - 3) The sound absorption coefficient of each core (if measured). Specify the results both for each core and each frequency range, as well as the overall average;
 - 4) The locations in the test area from where the cores for absorption measurement have been taken;
 - 5) Texture depth, including the number of tests and standard deviation;
 - 6) The institution responsible for tests according to C-6.1.6(a) and C-6.1.6(b) and the type of equipment used; and
 - 7) Date of the test(s) and date when the cores were taken from the test track.

C-6.2 Documentation of Vehicle Noise Tests Conducted on the Surface

In the document describing the vehicle noise test(s) it should be stated whether all the requirements of this standard were fulfilled or not. Reference shall be given to a document according to C-6.1 describing the results which verify this.

ANNEX D

**Table 3 Guidelines for Deciding for Testing in Case of Modification Made
in Already Type Approved Vehicle**

[Clause 5.3(b)]

Sl. No.	Modification in Vehicle	Testing Criteria
(1)	(2)	(3)
(i)	Engine Type (<i>see 3.2.1.</i>), Capacity, Number and arrangement of cylinder	To be tested
(ii)	Change in maximum power	To be tested, if the power is increased in excess of 5 percent
(iii)	Approach speed for test at AA', due to change in parameter such as: Engine rpm at peak power, maximum governed rpm	To be tested, in case of decrease in excess of 5 percent
(iv)	Intake System	
	Air Filter Type	To be tested in case of any change
	Fuel System — Carburettor to FI or Vice versa	To be tested in case of any change
	Turbocharger, supercharger	To be tested in case of inclusion and deletion
(v)	Exhaust system — silencer, exhaust tube Internal Diameter, Tail pipe Internal Diameter and location	To be tested in case of any change in design
	Exhaust Tube Internal Diameter	To be tested in case of any change
	Tail pipe location	
(vi)	Transmission Ratio	If the engine rpm at line BB' is affected such that the gear in which test is conducted is not same
(vii)	Kerb Weight	To be tested if decrease in excess of 5 percent
(viii)	Tyre Size	To be tested if tyre diameter is reduced

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